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ME -1

CONNECTEDNESS DIMENSION OF PRODUCTIVE PEDAGOGIES IN STUDENT'S UNDERSTANDING TO CONCEPTS OF DIFFERENTIAL CALCULUS

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Abstract

Undergraduate students' understanding of concepts that they have learned usually is not long lasting. This is due to two aspects; first is the inappropriate teaching approach and the second is students' weakness in connecting their prior knowledge to comprehend a new topic. One of pedagogical frameworks that includes connectedness dimension is so called *Productive Pedagogies*. In this research, we implemented the framework, especially connectedness dimension in teaching the subject of Differential Calculus, topics Absolute Value, Range and Domain of functions, and Limit and Continuity of Functions for first year students of Mathematics Department of Unesa. We planned and tried a teaching approach that facilitates students to use their prior knowledge to understand the topics being taught. At the end of the teaching and learning process we gave students a quiz about the topics and analyzed their works and then triangulated the results by interviewing a number of students. The results show that students' level of connecting the topics to their prior knowledge plays a central role in understanding the concepts being taught.

Key words: connectedness, productive pedagogies, differential calculus

INTRODUCTION

In learning mathematics, very often students experience difficulties in understanding the concepts being taught. Some students may understand, but while trying to understand the concepts they do not realize about what prior knowledge they use. They do not really know the connection between their previous knowledge and the concepts being taught. For example, while being taught how to find the limit of a function, most students are skillful in calculating the limit value, but they do not really know why in the calculation they can cancel out a certain common factor/term in the expression, especially in rational functions.

On the other hand, according the preliminary survey result to students who took the subject of Differential Calculus, many of them experience difficulties in understanding the concepts due to the approach used by the lecturer does not stimulate students to be actively involved in the learning process, lecturer seldom uses contextual learning approach in order to facilitate students to have a better understanding toward the concepts being given.

As connecting prior concepts is very important for a person who wants to understand certain concept in mathematics, it is interesting to study about that topic by implementing a lesson plan that facilitates students to learn actively in order to understand the topic being taught. Meanwhile, we will study students' responses and activities during the process of teaching and learning, especially focused on how students connect their prior knowledge to the new concept that they are trying to understand during the process.

One of pedagogical frameworks that includes connectedness dimension of students in the process of understanding a concept is so called *Productive Pedagogies*. In this study we implement the framework for the topic Functions and Limit of Functions of Differential Calculus subject. The subject is given to first year students of Mathematics Department of the State University of Surabaya (Unesa), Indonesia.

MATHEMATICS AND CONNECTEDNESS

Mathematics is constructed empirically from human being's experiences in life, brought it into rational world, then processed by using reasoning and logic in order to form mathematical concepts. Mathematics has characteristics:

1. The objects are abstract
2. Based on logical truth
3. Taught gradually and continuously based on students' cognitive level
4. Interrelation between topics
5. Use symbols
6. Can be applied to other areas

James and James (1976) explained that mathematics is science about logics, figures, structures, and concepts that are interrelated one to another. Mathematics can be divided into three main areas: algebra, geometry, and analysis. Those areas are closely related to support each other's development.

Due to the connectedness between topics in mathematics, teachers need to understand the connected dimension of topics in mathematics in order to enhance students in understanding mathematics concepts through connecting between concepts and their prior knowledge.

CONNECTEDNESS DIMENSION OF PRODUCTIVE PEDAGOGIES

One of teaching and learning framework that consists of connectedness as its dimensions is productive pedagogies. Productive pedagogies consist of four dimensions, i.e., Intelectual Quality, Supportive Classroom Environment, Recognition of Difference, and Connectedness (The State of Queensland (Department of Education), 2002).

Connectedness is the accumulation of new information in long-term memory, adding new nodes to memory an connecting the new nodes with components of the existing knowledge network of the learner (Mayer, in Chinnappan (2008)). Mayer also identified that there are two types of connectedness: internal connectedness and external connectedness. Internal connectedness refers to the degree to which the new nodes of information are connected with one another to form a single well-defined schema. For example, a student might have developed a schema about whole numbers. The schema could include information about size of numbers and its operations. External connectedness refers to the degree to which newly established knowledge structures are connected with structures already existing in the learner's knowledge base. For example, in the context for proportion, a learner might be expected to relate a schema for proportion with schemas for ratio or fraction. These external connection between proportion

and ratio or fraction will impact on learner's ability to use them to solve problems or provide alternative representations. The new schema for proportion will strengthen both its internal structure (internal connectedness) and its connections to related schemas (external connectedness).

DISCUSSION

This action research is started from a survey result to first year student teachers of Mathematics Department of The State University of Surabaya (or Universitas Negeri Surabaya (Unesa)) with the purpose to obtain information about students' prior internal structure of schemas and schemas interconnection before following lectures on Differential Calculus. The survey is carried out by giving a pre-test followed by interviews to students. Second step is lesson planning that takes productive pedagogies especially connectedness dimension into account. Third step is implementation of the lesson plans being constructed into the classroom. Finally, giving a quiz followed by interviews.

The survey consists of problems that require explanation to clarify students' answer. The problems also require students to connect some concepts in order to solve them. Based on their answers toward the problems, five students are selected to be interviewed to deepen their reasoning and comprehension on the concepts they used in solving the problems.

Lesson planning is carried out by considering analysis results of the pre-test results and interviews that follow. The lesson plans include productive pedagogies especially connectedness dimension in the teaching and learning process. Each teaching and learning process emphasizes on skills of connecting between concepts to students. During each teaching and learning process an observation is undertaken to gather information to evaluate the process for refinement to the next teaching and learning process, especially on connectedness dimension.

Giving a quiz after the teaching learning processes is to assess students' ability in connecting between concepts, and then triangulates the assessment result by interviewing some selected students. Finally, drawing conclusion about connectedness dimension of students in learning topics in Differential Calculus is undertaken.

In short, all the steps of this action research is illustrated as follows.

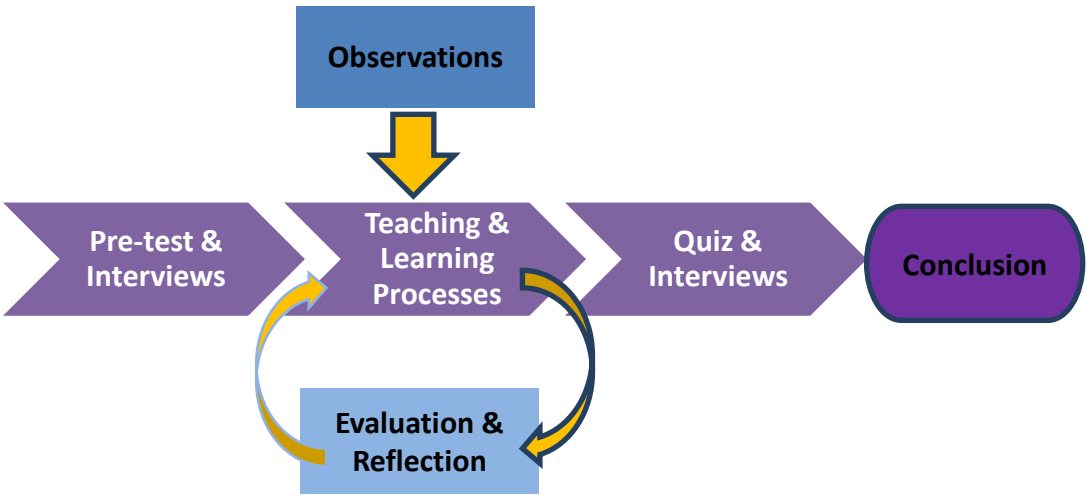

Figure 1. Research Method

The pre-test is constructed based on indicators that are intended to get information about students' prior internal and external connectedness of schemas. The following are indicators of the pre-test:

1. Explain how to determine the slope of a line equation you constructed.
2. Explain how to construct a line equation passing through two given points.
3. Explain how to determine the *x*-intercept and -intercept and *y*-intercept of a line.
4. Given a system of linear equations with two variable with an unknown coefficient, explain how to determine the unknown coefficient so that it can be concluded that the lines are paralel or perpendicular.

The pre-test with the above indicators expects the students use their knowledge they obtained from highschool. The scores of the pre-test of five selected students are then triangulated by interviewing them. From the pre-test and interviews results, it can be concluded that: (1) 3 out of 5 students do not really know the meaning of concepts, such as slope/gradient of a line, solutions of linear systems geometrically, etc. (2) Most of students only know the concepts mentioned in the pre-test by names and formulas introduced to them previously. Some students are able to produce "correct" answer, but they are not able to give the reason regarding the answer they made. Therefore, it can be said that the level of connectedness dimension of first year students of Mathematics Department of Unesa before Differential Calculus courses is low.

The lesson plans being constructed based on a number of indicators taken from the syllabus of Differential Calculus (Finney, et.al) that follow:

1. Solve equation involving absolute values.
2. Solve inequality involving absolute values.
3. Determine the domain and range of various functions.
4. Sketch the graph of function.
5. Determine the limit of functions.
6. Determine the continuity of functions in its domain.

The implementation of the lesson plans in the classroom gives emphasize on the approach that stimulates students to learn how to use their prior internal structure of schemas and schemas interconnection in Differential Calculus. Therefore, for achieving those indicators the lecturer should keep involving students and their prior knowledge in the process of teaching and learning. For example, when explaining how to solve equation involving absolute values, lecturer should stimulate students to recall their knowledge in solving equation that they got in highschool. During each teaching and learning process, an observation is held to guarantee that the process is undertaken as planned. If not, then the next lesson plan for the next meeting is refined so that similar unaccomplished segments in the previous meeting will not be happened again. The following table summarizes the observations held during the first and second meeting followed by the suggestions based on unaccomplished segments during the meetings.

Table 1. Summary of refinement suggestion for the next meeting

Topics	**Planning**	**Unaccomplished/ Suggestion**
Interval and absolute values	• Reminding various sets of numbers • Explaining intervals of real number and its graphs • Explaining how to determine solution of equation and inequality in terms of sets or intervals	• Appropriate number of examples • Use the steps and notations rigorously • Checking understanding by asking for explanation

Equation and inequality involving absolute values	• Reminding about solving equation and inequality in terms of sets or intervals • Copying the procedure to solve equation involving absolute values • Differentiating equation from inequality involving absolute values • Reminding about solving algebraic inequality by example • Copying the procedure to solve inequality involving absolute values	• Reminding that problems in solving equation and inequality may occur in solving equation and inequality involving absolute values

The quiz is constructed based on the indicators mentioned above. The quiz and the interviews that follow will be used to describe the level of connected dimension of productive pedagogies of the students. From the quiz and interviews result, it can be concluded that: (1) There are some students have a misconception about the definition of absolute values, even though most students produce correct conclusion (with minor mistakes), (2) All students are able to determine domain and range of functions correctly, moreover they elaborate their answer with graphs, (3) All students are able to use the limit concept to conclude the existence of limit of function at a certain point with approriate reasoning and elaborate the answer with graphs, (4) All students are able to use the limit concept and the condition for continuity of function to conclude the continuity of functions.

CONCLUSION

The results of this research show interesting phenomena in terms of students' ability in connecting their knowledge in order to master topics in Differential Calculus. Surprisingly, their level of connectedness dimension of productive pedagogies is so low that is insufficient to follow the introductory part of the course. However, after being taught involving their prior knowledge during the process of teaching and learning their ability in connecting their knowledge plays a central role in understanding the concepts being taught. This fact shows the importance of students' awareness of good mastery of prerequisites of a topics.

It is recommended to lecturers in mathematics department to pay more attention to connectedness dimension in preparing their teaching materials.

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